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Stability evaluation of different genotypes of pea (*Pisum sativum* L.) under different environment

Ram Avtar and Mohinder Singh

Abstract

The present study was undertaken to assess the differential response of 48 diverse genotypes of peas (*Pisum sativum* L.) over different environments and to estimate the genetic variability. In the present study the linear portion of genotype x environment interaction was significant for the characters days to plant height, number of pods per plant, seeds per pod, 100 seed weight and yield per hectare. Based on the environment index, environment E_1 was observed to be the most favorable environment for yield and most of its contributing traits. The genotypes included in the present study did not exhibit uniform stability and responsiveness pattern of different traits. None of the genotypes was found suitable with respect to all the traits. Considering the seed yield and its contributing trait; HFP-9907B was observed to be promising stable for six traits and DMR51 was observed to be promising stable for five traits. The other promising genotypes namely Jayanti, IFPD-3-6, HFP-9907A, HFP-2008, and KMPR 706 were observed to be stable and average responsive for four traits, as indicated by their high mean performance, average to above average response and non significant $\bar{s}^2_{di}$ values. Characters like length of pod, had relatively low genetic variability as well as genetic advance. Length of pod, yield per plant and yield per hectare showed low to medium heritability. The important attributing characters for yield such as days to 50% flowering, days to maturity, pods per plant and primary branches per plant had high heritability. Breeding through selection for these traits for improving seed yield may prove fruitful. Implications of these results have been discussed in the present study.

Keywords: Stability evaluation, genotypes of pea, environment

Introduction

In India pea occupies an area of 7.93 lakh hectares with total production of 7.10 metric tones with average productivity of 895 Kg per hectare (Banergee and Palke, 2010) [1]. Among pulses, field pea (*Pisum sativum* L.) is an important crop grown during cool weather for fresh green seeds, tender green pods, dried seeds and foliage. It is also an important off season crop of hills fetching premium price in the plains. Green peas are eaten as cooked vegetable and are marketed fresh, canned, or frozen while ripe dried peas are used as a whole, split or made into flour. They also synthesize a wide range of natural products such as flavor, drugs and dyes. To keep the pace with the nutritional demand of increasing population, high yielding pulse crop especially field pea varieties with wider adaptability and diversity than the existing ones is very important. The knowledge of genetic variability present in the breeding material and the part played by the environment in the expression of different traits is essential for the breeding of varieties for different agro climatic zones. Pea yield is highly sensitive to weather fluctuations as this shows high magnitude of genotype × environment interactions (Phul *et al.* 1997) [2]. The existence of genotype x environment interaction creates manifold difficulties in interpreting the results from the experiment conducted in different environments {Salmon (1951) [3], Horner and Frey (1957) [11] and Sandson and Bartlet (1958) [4]. Narsinghani and Rao (1981) [8] investigated that the genotype x (environment) year interaction was significant for number of days to maturity, plant height, number of pods per plant, number of seeds per plant and seed yield per plant. Singh and Singh (2003) [5] studied the genotype x environment interaction and phenotypic stability of ten pea genotypes at three locations. They observed that variation due to genotype (G), environments (E), genotype x environment interactions were significant for all the traits, indicating varied phenotypic expression of genotypes in different environments. None of the genotypes was observed stable for all the traits.

Materials and Methods

The experiment was conducted to assess the genetic variability and phenotypic stability (g x e interaction) of genotypes. All the genotypes were grown at three locations *viz.*, Hisar, Bawal and Kaul for two years (2003-04) and (2004-05) thereby creating total of six environments.

Each genotype was raised in RBD with three replications in each of the environments during Rabi, 2003-04 and 2004-05. Six different environments as E1- CCS HAU, Hisar, E2- RRS, Kaul, E3- RRS, Bawal, E4- CCS HAU, Hisar, E5- RRS, Kaul, E6- RRS. All the recommended agronomic package of practices of CCSHAU was followed to raise the crop. The observations were recorded on *viz.* days to 50 per cent flowering, days to maturity, branches per plant, Plant Height (cm), number of pods per plant, Length of pod (cm), number of seeds per pod, 100 seed weight (g), Yield per plant (g), Yield per hectare (kgs).

Result and Discussion

Plant Height

The data in the Table 1 that the stability analysis of individual genotype revealed that 13 genotypes namely IFPD-3-6, DDR-70, DMR 7, HFP-9907A, HFP-2008, DMR 51, KPMR 706, KPMR 704, VL 43, KPMR-698, Pant P 48 and HFP-9426 had non-significant Bi and $\bar{s}^2_{di}$ value. Another seven genotypes had both the Bi and the $\bar{s}^2_{di}$ value significant. Fifteen genotypes had significant Bi value and 28 genotypes had significant $\bar{s}^2_{di}$ value revealing thereby the performance could not be predicted across the environments of these genotypes. Genotype HFP-0129 had the least plant height while genotype HFP-9426 had most plant height. Twenty-five genotypes had less plant height than average and remaining 23 genotypes had more plant height than average. Genotype IFP 3-71 and number of pods (21).

Rachna had high mean and high Bi value but significant $\bar{s}^2_{di}$ value so these are not stable. Kalloo *et al*. (1979) [10] reported highly significant differences between genotypes and environments in a study of stability analysis of twelve varieties of pea for four years for pod yield. Narsinghani and Rao (1981) [8] investigated that the genotype x (environment) year interaction was significant for number of days to maturity, plant height, number of pods per plant, number of seeds per plant and seed yield per plant.

Number of pods per plant

The data in Table 1 indicate that 21 genotypes had both Bi and $\bar{s}^2_{di}$ values to be non significant. Twelve genotypes had their both Bi and $\bar{s}^2_{di}$ values significant. Twenty-five genotypes had Bi value significant and 14 had $\bar{s}^2_{di}$ value significant. number of seeds per plant and seed yield per plant. Gupta *et al*. (1984) evaluated twelve parental lines and their F_1s under six different environments by changing the sowing dates and reported that both linear and non linear components of genotype × environment interaction were significant for 100 seed weight and seed yield per plant. Genotype 37 had the highest number of pods per plant (34.10), 19 genotypes had more than average number of pod, 3 genotype bear equal to mean number of pods and 26 genotypes less than average

Table 1: Estimates of stability parameters [Perkins and Jinks (1968a)] for plant height and numbers of pods (per plant)

Sr. No.	Genotypes	Plant Height			No. of pods (per plant)		
		Mean	Bi	Sd^{-2}	Mean	Bi	Sd^{-2}
1 Dwarf	HFP-0106	64.25	.30	-351.96	25.38	1.069*	-.62
2 ’’	HFP-0127	71.41	.14	-508.63**	24.70	.62*	-2.30
3 ’’	HFP-0128	83.93	.73*	740.43**	22.91	1.06*	-4.02
4 ’’	HFP-0129	51.39	.18	-547.65**	18.79	-.06	-3.39
5 ’’	HFP-0132	71.46	-.07	-564.52**	28.12	1.17*	12.04**
6 ’’	HFP-0133	81.48	.24	-497.32**	20.15	-.07	-5.34
7 ’’	HFP-0143	60.07	.11	-553.56**	17.98	-.24	-2.54
8 ’’	JAYANTI	68.10	-.18	-383.03*	19.83	.03	4.98**
9 ’’	Pant P-26	83.63	.59*	-266.92	13.33	-.92*	6.34**
10 ’’	IPFD-3-6	62.28	-.31	-315.21	16.86	-.32*	-4.06
11 ’’	RFP-4	113.86	.6*	-142.20	24.07	.54*	-.96
12 ’’	DDR-70	89.70	-1.95*	155.34	21.48	.19	.32*
13 ’’	IPFD 3-7	50.50	-.28	-488.80**	27.26	1.21*	15.14**
14 ’’	DDR 69	66.44	.36	-475.31**	22.62	.21	-5.07
15 ’’	Pant P 25	74.10	.25	-471.54**	19.02	1.25*	14.56**
16 ’’	RFD 3	73.80	.06	-462.79**	18.44	.17	-5.24
17 ’’	HUDP 26	60.43	-.05	-460.95**	20.35	.24	-3.78
18 ’’	KPMR 683	74.51	-.27	-436.98**	18.89	.15	-5.16
19 ’’	KPMR 682	80.75	-.14	-414.45**	19.92	-.07	-4.65
20 ’’	IM 3001	66.10	-.19	-550.36**	22.50	-1.02*	-3.92
21 ’’	LFP 363	59.78	-.02	-584.65**	14.02	-.80*	4.42**
22 ’’	DMR 7 (ch) Tall	164.87	-.05	-190.64	15.72	-.13	-4.04
23 ’’	HFP 4 (ch)	64.94	-.15	-547.72**	24.86	.53*	-1.20
24 ’’	KPMR 522 (ch)	70.65	-.68*	698.03**	14.09	-.78*	4.84**
25 Tall	HFP-0110	123.78	.71*	430.26**	21.11	1.04*	-5.12
26 ’’	HFP-0118	87.33	-.14	-560.70**	16.06	-.77*	2.57**
27 ’’	HFP-2005	170.67	.68*	287.62	15.98	-1.14*	13.72**
28 ’’	HFP-9907A	178.72	.05	185.86	23.81	.13	-4.80
29 ’’	HFP-9907B	187.41	-.19	-521.55**	21.98	-.02	-5.00
30 ’’	HFP-2008	200.72	-.21	-156.90	19.84	-.20	-5.05
31 ’’	RACHNA	192.98	.27	554.42**	20.92	-.15	-3.96
32 ’’	DMR 51	163.92	.20	-221.43	25.34	.31*	-1.82

33 ’’	IFP 3-17	153.46	.97*	431.67**	20.85	-.33*	-3.41
34 ’’	KPMR 706	165.15	-.31	-5.10	14.57	-.63*	-.05*
35 ’’	HFP 2008 retesting)	150.20	.50*	-102.91	20.96	-.21	-4.69
36 ’’	VL 44	132.81	-.77*	676.38**	21.35	-.07	-4.83
37 ’’	KPMR 704	133.04	-.17	46.41	34.10	1.18*	12.60**
38 ’’	DMR 52	158.38	.50*	-370.61*	21.13	-.33*	-4.11
39 ’’	VL 43	145.09	.09	-329.78	23.35	-.28	-4.12
40 ’’	KPMR-698	165.88	.36	50.64	29.07	.51*	-2.01
41 ’’	HFD 2005	169.70	1.12*	149.10	16.51	-.77*	3.18*
42 ’’	Pant P 48	143.40	.03	-127.08	23.12	-.02	-4.60
43 ’’	IFP 3-13	129.68	.43*	-416.34**	22.26	-05	-2.11
44 ’’	DMR 7 (ch)	149.47	.24	-430**	19.85	-.23	-4.02
45 ’’	DMR 49 (retesting)	174.16	.07	-432.28*	24.40	.29	-4.39
46 ’’	KPMR 7 (ch Dwarf)	78.02	-.65*	186.27	18.90	-.46*	2.28*
47 ’’	Rachna (ch)	136.35	.84*	128.43	21.00	-29	-3.39
48 ’’	HFP-9426	135.14	-.23	263.39	17.31	-.55*	-1.35
	Mean	115.29			21.02		
	S.E. (M)	.154	.15		.104	.18	

Table 2: Estimates of stability parameters [Perkins and Jinks (1968a)] for 100 seed weight and yield per hac. (kgs)

Sr. No.	Genotypes	100seed weight			Yield/ha (kgs)		
		Mean	Bi	Sd^{-2}	Mean	Bi	Sd^{-2}
1 Dwarf	HFP-0106	21.09	-1.34*	.77*	1938.05	1.14*	928564.6**
2 ’’	HFP-0127	19.10	-.86*	.80*	2577.67	1.01*	794746.7**
3 ’’	HFP-0128	22.37	1.62*	-1.54	2508.22	.86*	452579.2**
4 ’’	HFP-0129	19.78	.06	-.41	2311	.58	889356.2**
5 ’’	HFP-0132	21.72	-.59*	5.80**	2242.5	.29	322039.9**
6 ’’	HFP-0133	20.43	-.79*	1.48**	2591	.58	180322.2**
7 ’’	HFP-0143	18.09	-.45	1.52**	2261.44	-.01	746404.6**
8 ’’	JAYANTI	19.08	-.42	-1.02	2530.89	-.40	465787.6**
9 ’’	Pant P-26	20.68	-.95*	-.22*	2615.22	.06	984843.6**
10 ’’	IPFD-3-6	19.27	.30	-.03*	2217.11	-.84*	440973.6**
11 ’’	RFP-4	19.51	-.17	-2.09	2496.27	-.14	70467.5**
12 ’’	DDR-70	25.16	1.03*	2.15**	2297.33	.80*	146212.3**
13 ’’	IPFD 3-7	19.52	-.53*	-.66	2450.72	-.08	14575.7*
14 ’’	DDR 69	18.95	-45	2.70**	2883.27	.68	927629.3**
15 ’’	Pant P 25	20.34	.55*	3.81**	2789.16	.37	34463.9**
16 ’’	RFD 3	20.30	.23	.71*	1687.61	-.21	290469.6**
17 ’’	HUDP 26	18.54	-.77*	-1.16	2417.83	.06	4944.1**
18 ’’	KPMR 683	24.81	.74*	.95*	2349.66	-.64	32599.8**
19 ’’	KPMR 682	21.22	.18	3.22**	2056.06	-.74*	2099.9*
20 ’’	IM 3001	17.78	-.09	3.04**	2349.61	-.47	110624.8**
21 ’’	LFP 363	18.35	-.40	1.48**	2335.06	.06	93347.8**
22 ’’	DMR 7 (ch) Tall	21.70	.64*	-1.02	2364.28	-.49	221769.8**
23 ’’	HFP 4 (ch)	19.42	.55*	-1.57	2523.94	.07	147826.2**
24 ’’	KPMR 522 (ch)	22.18	.54*	1.02*	3608.72	.51	64404.2**
25 Tall	HFP-0110	22.79	1.42*	-1.93	2544.00	-.19	963000.9**
26 ’’	HFP-0118	20.23	-.08	2.17**	2213.33	.80*	315073.3**
27 ’’	HFP-2005	21.18	-.58*	3.56**	2194.24	-.18	479078.4**
28 ’’	HFP-9907A	21.72	-.15	-.60	2195.56	.47	98371.6**
29 ’’	HFP-9907B	23.52	-.30	-1.34	1841.55	-.42	-5602.2
30 ’’	HFP-2008	21.96	-.21	-1.53	2691.17	-.15	684690.6**
31 ’’	RACHNA	19.79	-.41	-1.86	1723	-.84*	230366.0**
32 ’’	DMR 51	22.25	-.44	-1.43	2181.67	-.66	65692.8**
33 ’’	IFP 3-17	21.79	-.93*	.95*	1778.22	-1.92*	221951.6**
34 ’’	KPMR 706	21.10	-.20	-1.48	2410.89	.18	82141.4**
35 ’’	HFP 2008 (retesting)	21.17	-.40	4.90**	2388.83	.45	88672.4**
36 ’’	VL 44	20.60	.25	-1.67	2606.61	.01	29011.0**
37 ’’	KPMR 704	22.98	.98*	.63*	2163.62	.69*	80871.6**
38 ’’	DMR 52	21.79	-.26	1.00*	2369.06	.06	177280.2**
39 ’’	VL 43	23.65	1.64*	3.01**	1886.22	.25	238612.7**
40 ’’	KPMR-698	23.82	.55*	3.79**	2441.11	.58	124494.3**
41 ’’	HFD 2005	24.74	.50*	.97*	2447.27	-.04	134681.3**
42 ’’	Pant P 48	20.97	-.65*	-1.31	2061.56	-.60	184836.4**
43 ’’	IFP 3-13	21.03	.43	-1.32	2228.83	-.59	361859.6**

44 ’’	DMR 7 (ch)	21.53	.56*	2.72**	2721.22	-.39	653242.0**
45 ’’	DMR 49 (retesting)	22.27	-.13	-1.28	2771.33	-.27	302359.5**
46 ’’	KPMR 7 (ch Dwarf)	24.72	1.23*	4.25**	2236.44	.62	421516.9**
47 ’’	Rachna (ch)	27.66	1.30*	4.10**	1903.61	-.84*	755951.9**
48 ’’	HFP-9426	20.89	-1.42*	3.56**	2457.50	-.04	70063.6**
	Mean	21.18			2351.24		
	S.E. (M)	.90	.48		.26	.73	

100 seed weight

A perusal of Table 2 indicated that 12 genotypes had non-significant Bi and $\bar{s}^2_{di}$ value while 19 genotypes had both Bi and $\bar{s}^2_{di}$ value significant. Twenty-six genotypes had Bi value significant and 29 genotypes had $\bar{s}^2_{di}$ value significant. Genotypes DDR-70, KPMR 683, HFD 2005, KPMR (ch dwarf) and Rachna produced bolder seed accompanied by significant Bi and $\bar{s}^2_{di}$ value so these are unstable. Genotype HFP-9907A produced more than average seed weight and stable. Genotype KPMR 704 produced more than average having unity Bi value and $\bar{s}^2_{di}$ value non - significant so it was most stable to all environments.

Yield per hectare

Stability analysis of 48 genotypes revealed that 11 genotypes had both Bi and $\bar{s}^2_{di}$ value significant. Eleven genotypes had only Bi value significant and all 48 genotypes had $\bar{s}^2_{di}$ value significant. Genotypes KPMR 522 produced highest yield per hectare but was unstable due to its significant $\bar{s}^2_{di}$ value. Genotypes HFP-0127, HFP-0128, IPFD-3-6, RACHNA and Rachna gave high Bi near to unity but significant $\bar{s}^2_{di}$ value so these were not stable. Twenty-three genotypes produced more yield per hectare than average and remaining 25 genotypes produced less yield per hectare. Chetia and Yadav (2002) worked out genotype x environment interaction for seed yield and its component traits of thirty nine pea genotypes under four environments and observed significant differences (g x e interaction) for all the traits except for number of primary branches and 100 seed weight, indicating the differential behaviour of genotypes over the environments. Singh *et al.* (1996) [6] suggested high variability for plant height, pods/ plant and greenpod yield per plant. Tyagi *et al.* (2002) [7] observed a wide range of variability in field pea for plant height, pods per plant and biological yield per plant.

The results of mean, range, GCV, PCV, heritability and genetic advance (% of mean) have been presented in Table 3. A perusal of table 3 revealed that generally mean was found to be higher for the traits yield per hectare followed by days to maturity and plant height. Characters such that pod length, seeds per pod and primary branches per plant showed narrow range of mean and days to 50% flowering and yield per plant showed wide range of mean. Characters pods per plant and 100 seed weight have almost same mean. Kumar *et al.* (2003) [9] studied 32 strains/varieties of pea to asses genetic variability. The analysis of variance revealed that wide range of variability for plant height, days to maturity, days to flowering, numbers of pods per plant, grain yield per plant and harvest index. Estimates of GCV and PCV were highest for grain yield per plant, followed by number of pods per plant, number of seed per pod and 100 seed weight.

A perusal of coefficient of variation in the Table 3 showed that phenotypic coefficient of variation is higher than their corresponding genotypic coefficient of variation. It was because of the fact that PCV include environmental component also. By comparing GCV and PCV for pod length, yield per hectare and seed per pod, a large gap in GCV and their corresponding PCV was indicating that these characters are more sensitive to environment.

Table 3: Genetic parameters of variation for yield and its attributes in field pea in pooled Environments

Sr. No.	Traits	Range	Mean	PCV%	GCV%	Heritability (h^2)	GA% of mean)
1	Days to 50%flowering	72.50-91.05	81.09	8.44	5.91	0.92	8.54
2	Days to maturity	122.66-134.33	129.15	5.77	5.13	0.87	9.39
3	Plant height	50.50-235.34	115.29	46.09	36.19	0.61	58.53
4	Pods per plant	13.33-34.10	21.02	39.12	27.95	0.85	41.14
5	Pod length	5.43-7.62	6.68	29.07	6.20	0.45	2.72
6	Seeds per pod	3.81-6.03	5.09	16.97	9.52	0.71	11.01
7	Primary branches per plant	1.71-3.40	2.59	22.85	13.28	0.83	15.90
8	100seed weight	16.03-26.37	21.18	19.09	10.16	0.78	11.15
9	Yield per plant	4.34-24.36	10.69	48.85	37.43	0.60	59.07
10	Yield per hectare (kgs)	1556.5-3481.83	2351.24	30.87	18.26	0.55	22.25

Seeds per pod and 100 seed weight showed 60-70 percent heritability and yield per hectare 55% with 60% heritability. An examination of Table 3 further revealed that genetic advance for different characters varied appreciably. Out of ten characters, yield per plant, plant height and pods per plant showed high; yield per hectare, primary branches per plant, 100 seed weight and seeds per pod showed medium; and pod length, days to 50%flowering and days to maturity showed lower value of genetic advance. Singh and Mir (2005) reported high GCV and PCV for numbers of branches per plant, numbers of pods per plant, seed yield per hectare and average seed yield per plot. High heritability was observed for seed yield per hectare, average seed yield/plot, numbers of pods per plant and days to 50% flowering. When heritability and genetic gain were considered together seed yield/ha, average seed yield/ plot and numbers of pods /plant were recorded highest value for both, however number of branches /plant, pod length, plant height and pod diameter were recorded moderate heritability with higher genetic gain.

Table 4: Environmental index of ten characters of field pea under six environments

Sr. No.	Character	E1	E2	E3	E4	E5	E6
1	Days to maturity	2.159	-0.340	-5.340	5.173	-3.826	2.143
2	Days to 50% flowering	2.458	-4.541	-3.541	11.875	-7.125	0.875
3	Plant height	16.485	5.085	-14.648	-6.789	3.817	3.693
4	Number of pods per plant	8.364	1.726	-0.065	2.678	-6.503	-6.259
5	Length of pods	0.216	-0.225	0.465	0.175	0.162	-0.569
6	Seeds per pod	0.215	0.365	-0.653	-0.213	-0.179	0.465
7	Primary branches per plant	0.268	0.207	-0.171	0.168	0.068	0.541
8	100 seed weight	2.133	-1.218	1.573	0.808	-2.801	-0.459
9	Yield per plant	5.027	0.593	-5.812	1.483	-1.304	0.113
10	Yield per hectare	438.655	190.655	-131.615	180.814	-75.518	-602.990

Data in the Table 4 indicated that Environment E_1 was favorable for plant height, number of pods per plant, seeds per pod, 100 seed weight, yield per plant and yield per hectare. Environment E_6 was favorable for primary branches per plant. Thus, environment E_1 was observed to be the most favorable environment for yield and most of its contributing traits.

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